

## 3.—CONTRIBUTIONS TO THE MINERALOGY OF WESTERN AUSTRALIA.

## SERIES VIII.

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(With two figures.)

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## (1) ANTIMONY OCHRE, WILUNA, CEN.

The most important bodies of gold ore at Wiluna are N. and S. shear zones in carbonated and chloritised Precambrian dolerite. These are practically free from antimony minerals, the only abundant sulphides in them being arsenopyrite and pyrite. Crossing the lodes more or less at right angles are a number of small quartz reefs of later age which are also auriferous, and often highly so. These, below water level, carry bunches of stibnite, and, nearer the surface, corresponding masses of "antimony ochre" derived from its weathering.

This "ochre" is microgranular, dense and hard, and intimately intergrown with granular quartz. In colour it is usually dull or bright yellow, but not uncommonly grey, and occasionally almost white. Sometimes the whole mass, which may reach many pounds in weight, is of almost uniform colour and texture. Quite often it is distinctly banded in concentric lines representing interrupted stages of oxidation, with at times a central core of unaltered stibnite.

In the Moonlight gold mine (G.M.L. 870), stibnite and dense antimony ochre are particularly plentiful in one of these quartz veins. On the old mine dump, when inspected by the Writer in 1932, many beautiful examples were to be seen of the rhythmical oxidation of stibnite to stibiconite and other oxidised products. The accompanying Fig. shows one such with a small patch of residual stibnite at the top near the right side, the balance of the specimen being an intimate mixture of quartz and antimony oxides, banded in different shades of yellow and grey. For the excellent photograph of this specimen I am indebted to the kindness of Mr. H. J. Smith of the Geology Department of the University.

To shed some light on the composition of the oxides, an analysis was made of a specimen showing no banding but only a slight blotchiness in



colour. It was very hard and dense in texture. Specific gravities of various chips ranged from 3.8 to 4.0, indicating an uneven distribution of quartz.

The analytical results were:—

ANTIMONY OCHRE, WILUNA.

$\text{Sb}_2\text{O}_4$	$\text{Fe}_2\text{O}_3$	$\text{Al}_2\text{O}_3$	$\text{CaO}$	$\text{MgO}$	$\text{H}_2\text{O} +$	$\text{H}_2\text{O} -$
61.79	.25	.50	3.51	.19	2.15	.45
$\text{SO}_3$	$\text{SO}_3$	$\text{CO}_2$	$\text{SiO}_2$	Total.		
Water sol.	Acid sol.					
.14	nil	nil	30.25	99.23*		

Analyst: C. R. LeMesurier.



ANTIMONY OCHRE, WILUNA.

Showing rhythmical weathering of stibnite.

Scale of Nature.

Photo., H. J. Smith.

Fig. 1.

\* Add 0.48 per cent. extra oxygen if  $\text{CaO}$  is present as atopite.



Rejecting (1) the silica which, except for a little kaolin, was proved to be present as quartz, (2) the water soluble  $\text{SO}_3$ , and an equivalent amount of  $\text{CaO}$  and  $\text{H}_2\text{O}$ , together present as gypsum, and (3) the  $\text{Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$ , etc., existing as kaolin and limonite, one is at once struck with the appreciable remnant of lime which may be present as atopite.\* It is evident that both stibiconite and cervantite are present, the approximate proportions being—

Stibiconite, $\text{Sb}_2\text{O}_4 \cdot \text{H}_2\text{O}$	...	...	...	55.2 per cent.
Cervantite, $\text{Sb}_2\text{O}_4$	...	...	...	25.3 „
Atopite, $\text{Ca}_2\text{Sb}_2\text{O}_7?$	...	...	...	19.5 „
				100.0 per cent.

E. S. Larsen in 1921† noted, optically, the complexity of an antimony ochre labelled “cervantite” from Western Australia, possibly from Wiluna. In the banded specimens stibiconite and cervantite appear to form alternating layers.

#### APATITE, BARITE AND GLAUCONITE, GANTHEAUME BAY, MUR.

Towards the end of 1932 the writer had occasion to visit the lower reaches of the Murchison River, where for about fifty miles it flows through a deep gorge before reaching the sea in Gantheaume Bay. The walls on the south side of this gorge are about 800 ft. high and consist essentially of reddish sandstone (Jurassic?). The north side is somewhat higher, the sandstone being overlaid by glauconitic sands and shales, and finally capped by chalk, both of proved Cretaceous age.‡ As at Gingin and Dandaragan, 250 miles to the south, apatised wood and coprolites occur at the junction of the chalk and glauconitic material, whilst barite was found in the latter associated with gypsum.

*Apatite.*—Amongst the talus of Thirindine Bluff, ten miles north-east of the mouth of the river, a large number of specimens of fossil wood up to 7 or 8 lbs. (3 or 4 kilos) in weight have been found, the petrifying medium being mainly fluorapatite, a partial analysis showing  $\text{P}_2\text{O}_5$ , 30.60 per cent; F, 2.74 per cent., equal to 72.6 per cent. of  $\text{Ca}_5\text{F}(\text{PO}_4)_3$ . Outwardly they resemble the apatised wood (Cedroxylon), which is so plentiful at Dandaragan, but rare at Gingin, on precisely the same horizon.§ The Gantheaume Bay specimens are all fragments of stems or limbs, in which the annual growth rings are plainly visible to the unaided eye. Occasional “knots” are seen, where branches have once grown, and holes made by boring organisms are very common, as at the two southern localities. These holes, averaging 0.25 to 0.5 inch (6 to 12 mm.) in diameter, are usually filled with a firm granular mixture of apatite, chalk and glauconite.

Examination of cross, tangential and radial sections under the microscope shows that the cell structure is beautifully preserved. In cross section the tracheids are thin walled and partly air filled, partly filled with dense apatite. In radial section, rows of pits can be seen in the walls of

\* Cf. Natta and Baccaredda; Z. Kr. 85, p. 271 (1933); Minl. Abs. 5, p. 294 (1933).

† *Micr. Det. of Nonop. Minerals*, p. 55.

‡ Mr. L. Glauert has recognised a number of typical fossils in both series.

§ E. S. Simpson, *Jour. Nat. Hist. Sc. Soc. W.A.* 4 (1912), pp. 33-37.



the tracheids, sometimes single, sometimes double. In the latter case the longitudinal spacing is not quite even, so that some pairs of pits are opposite, others alternate. Medullary rays are fairly numerous, and are composed of three to ten cells in a single series. The wood appears to be that of a conifer, similar in structure to the apatised wood at Dandaragan.

When the wood is crushed or ground down for section making, some pieces, if not all, emit a strong fetid odour, approaching that of a mixture of hydrogen phosphide and sulphide.

Associated with the apatised wood at Thirindine Bluff, there are a few coprolites, the largest one seen being 12 inches in length and 3 inches in diameter (30 x 7 cm.). At a second locality, White Cliff, overlooking the river only four miles from its mouth, these bodies are very plentiful. Here they are to be seen in position, associated with flints, in the lower portion of the chalk bed. They are spherical, oval or cylindrical in form, and vary in weight from a few ounces up to 2 or 3 lbs. Most of them are greyish black in colour on the surface, and pale yellowish grey on a fresh fracture. They are dense, hard and tough. Although easily separable from the soft chalk matrix, being in such a remote locality, there is little probability of any industrial use being made of them for the present.

The phosphoric oxide content was determined on three characteristic specimens, the results being 28.42, 28.84 and 29.10 per cent. Finally a complete analysis was made of one of them with the following results:—

COPROLITE, WHITE CLIFF, GANTHEAUME BAY.

CaO	MgO	FeO	MnO	P <sub>2</sub> O <sub>5</sub>	F	Cl	H <sub>2</sub> O +	H <sub>2</sub> O —
46.63	.48	traces	.04	29.10	2.44	.17	3.97	.90
SO <sub>3</sub>	CO <sub>2</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Org	Total.
1.50	5.12	.66	.46	.53	1.93	5.53	1.60	101.06
Less O ≡ F <sub>2</sub> + Cl <sub>2</sub>								1.07
Net Total								99.99

Analyst: C. R. Le Mesurier.

The usual humus factor 1.724 was used in calculating the organic matter from the carbon determined by wet combustion. Of the SO<sub>3</sub>, 0.20 per cent. was water soluble, 1.30 per cent. soluble in HCl.

Calculation from these figures, using the microscope section as a guide, indicates that the coprolite consists, to the extent of about 78 per cent, of fluorapatite with a ratio F:OH equal to 17:1. In addition the following minerals are intimately intergrown with it: calcite, glauconite, gypsum, a basic ferric sulphate (natrojarosite?), quartz, kaolin and organic matter.

Although CO<sub>2</sub> is present in the coprolite there is no evidence whatever of any "carbonato-phosphate," nor "oxyphosphate" such as is postulated by some authors who either fail to look for fluorine, or to determine it accurately.

*Barite.*—A few concretionary masses of dense barite with an oolitic surface were found associated with gypsum in a Lower Cretaceous shale underlying the chalk at "White Cliff." The specific gravity in mass is 4.17, and the usual chemical reactions have been observed. The barium of the nodules is probably derived from the chalk, and the sulphate ion from the oxidising marcasite or pyrite concretions which are common in the shale.



*Glaucinite*.—In addition to the glauconite already mentioned as occurring throughout the coprolites, and as a constituent of the filling of worm holes in the fossil wood, the mineral is abundant in the sandy and clayey beds underlying the chalk.

At White Cliff there are banks of dark green (Ridg. 25<sup>3</sup>l) sand, which appears under the microscope to contain about 80 per cent. of dark olive green to olive brown, translucent, glauconite. This is in subangular, mammilated and rounded granules, some of which are clearly internal casts of foraminifera. Their diameter ranges from 0.02 up to nearly one millimetre. All of them, even the smallest, are made up of a compact mass of minute, highly birefringent scales.

Under the chalk at Thirindine Bluff is a rusty white sand with an efflorescence of sulphate. Microscopic examination of this reveals much quartz, with about 20 per cent. of olive brown glauconite. Much of it is in granules similar to those at White Cliff. Some, however, are deeply corroded, and all have a thin coating of rusty material. This is probably to be accounted for by the action of acid solutions resulting from the weathering of pyrite or marcasite concretions. This suggestion is supported by the low percentage of acid-soluble potash left in the sand, viz., 0.53 per cent., which is only equivalent to about 7.5 per cent. of unaltered glauconite, a figure far below that derived from microscopic examination, and by the sulphate efflorescence.

At the few spots where the chalk was examined closely, it appeared to be singularly devoid of glauconite granules.

#### NATIVE ARSENIC, KALGOORLIE, CEN.

Through the courtesy of Messrs. S. F. C. Cook and R. F. Playter, of Kalgoorlie, the writer has been able to examine a small specimen of native arsenic obtained from the 1,537ft. level in Chaffer's Gold Mine, at Boulder, Kalgoorlie. The specimen was found in a vugh in the Great Boulder main lode (which is identical with the Horseshoe No. 4 lode) at a point about 100 feet south of Chaffer's shaft. This lode is a silicified and carbonated shear zone is a chloritised quartz dolerite of Precambrian age. The vugh was lined with crystals of quartz and dolomite, on to which the arsenic had grown in the form of a mammilated mass about 25 mm. (1 inch) thick. It is thus the latest mineral to form in the lode. Internally, the mass was rather coarsely crystalline, with an obscurely radiated structure.

A freshly broken surface of the mineral has a greyish metallic lustre, which tarnishes in less than an hour to a rather dull black with faint iridescence. The clean mineral has a specific gravity of 5.85. A few small fragments were analysed. They showed 97.3 per cent. of arsenic, with appreciable quantities of vanadium, iron and oxygen. The mineral dissolves readily in warm dilute nitric acid.

The first record of native arsenic in Australia is that of W. F. Petterd, who in 1910 noted its presence in two tin mines at Mt. Bischoff, Tasmania.\* In 1913 B. Dunstan recorded the mineral in Queensland, at Dargalong, with silver-lead ore, with gold at Charters Towers, Kilkivan, and Gympie, and also in a non-auriferous quartz reef at Gympie.† C. Anderson in 1916 gave

\* Cat. of the Minerals of Tasmania, p. 13.

† Queensland Mineral Index, p. 20.



Castlemaine, in Victoria, as a further locality, presumably in association with gold\*. Finally, in 1926, George Smith mentioned its occurrence in New South Wales in several parts of the Drake district, including Lunatic, as well as at Forbes, where it was observed in some of the richest gold ore.†

The mineral has never previously been observed in Western Australia, and it is noteworthy that it should have been found at a place where the gold ores in bulk contain only minute traces of arsenic, and that usually in the form of fahl ore, small crystals of arsenopyrite and realgar being very rare. Both arsenic and realgar appear to be two of the last minerals to be formed in the Kalgoorlie lodes.

#### (4) BERYL, MELVILLE, MUR.

From the information collected by the writer and others on the spot during the last two years, it would appear as if Melville were one of the most important localities for beryl in the State. Three varieties of the mineral have been recognised there, viz.:—

- (1) Common beryl.
- (2) Emerald.
- (3) Rosterite (Caesium-beryl).

The area where it occurs covers a junction between Precambrian granite and amphibolite, and is remarkable for the ragged interpenetration of the two rock masses, and for the large number of quartz-felspar pegmatites traversing both. As a consequence of the chemical activity of the potash-bearing solutions accompanying the pegmatites, the amphibolite on one or both sides of the veins for a width of several feet is frequently converted into a biotite schist. The different varieties of beryl have been found within the amphibolite area, either in the pegmatite veins, or more rarely in the selvage of biotite schist.

*Common beryl.*—This occurs only in the pegmatite veins, where it forms either large masses up to well over 50 lbs. (23 kilos) in weight, devoid of crystal outline, or else prismatic crystals from a fraction of an inch up to 16 inches in diameter (about 5mm. to 40 cm.). Large masses capable of commercial development were noted at four points, viz., 20 chains N.E. of the "The Basin,"‡ 20 chains north of the first place, midway between Santa Claus M.L. 29 and Harrison's Reward M.L. 26, and lastly on the latter lease.

The large masses and crystals show no certain age relationships to the surrounding quartz and feldspars, but the smaller crystals in the pegmatites are mostly completely embedded in quartz. In addition several were seen entirely embedded in a single microcline crystal, and two others in albite.

As regards form,  $m$  ( $10\bar{1}0$ ) by itself is very common, and a combination of  $m$  and  $i$  ( $21\bar{3}0$ ) fairly common. Three small crystals appeared to be a combination of  $m$  and  $a$  ( $11\bar{2}0$ ). In only one case were small faces of  $s$  ( $11\bar{2}1$ ) observed. The basal plane was not seen except as a parting, and in many cases even this parting was lacking.

\* Bibliog. of Australian Mineralogy, p. 87, 96.

† Mineralogy of N.S.W., p. 9, 13.

‡ Local name for a circular hollow in the amphibolite hills,  $2\frac{1}{2}$  miles N.N.W. of the town.

The colour of the common beryl is fairly variable. A series of tints between a green and a blue, roughly lying within Ridgways 39" b-f and 41" b-f, is widespread. These tints pass in patches, or in rare whole crystals, into a true sky blue or orient blue on the one hand, or into an emerald green (see below) on the other. Occasionally one notes a true green passing, in associated crystals, through yellowish green to greenish yellow (approximately 25' i, 23' k, 23' i, 19' i). Finally pale amber is a common colour in the larger masses and crystals, and one crystal was seen of a deep amber (near 16' i). It is not uncommon to find amber and blue-green, or blue, crystals in the same pegmatite vein.

The translucency of all this "common beryl" is of an inferior order. It is quite common in a crystal to see a network of beryl of low translucency surrounding small "eyes" of almost transparent mineral. The lowered translucency is usually due to innumerable microscopic inclusions of gas or liquid.

*Emerald.*—True emerald of inferior quality was found just south of the place known as "The Basin." It occurred in a quartz-microcline-albite-topaz pegmatite, and more abundantly and of better quality in the biotite schist flanking it. For lack of capital the deposit has only been prospected on a very small scale, and so far without remunerative results.

The mineral is in prismatic crystals from 2 to 20 mm. (0.1 to 0.8 inch) in diameter. They range in colour from greenish white through many tints of green to deep emerald. The translucency varies greatly from crystal to crystal, and even within a single crystal small portions may be completely transparent, whilst other portions possess only a low translucency. Many of the crystals obtained have been very promising in colour and lustre, but none quite clear enough over a sufficient space to warrant cutting.

*Rosterite.*—Of special interest is the occurrence of this rare caesium-bearing variety of beryl in a quartz-microcline pegmatite 100 yards east of the abandoned bismuth workings on Harrisons Reward M.L. 26. On reputable authority it is stated that about 10 cwt. (500 kilos) are visible along the outcrop. An analysis yielded the following figures:—

## ROSTERITE, MELVILLE.

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	BeO	MnO	Li <sub>2</sub> O	Na <sub>2</sub> O	K <sub>2</sub> O
64.64	19.10	.14	11.32	trace	.17	.31	trace
	Rb <sub>2</sub> O	Cs <sub>2</sub> O	H <sub>2</sub> O +	Total.	G.	No	Ne
	1.42	1.72	1.21	100.03	2.74	1.584	1.5785

Analyst: D. G. Murray.

No traces were detected of Cr<sub>2</sub>O<sub>3</sub>, FeO, MgO, CaO, or CO<sub>2</sub>. The analysis revealed quite considerable amounts of both rubidium and caesium. Like all other rosterites, it has a higher specific gravity and refractive index than common beryl. Hand specimens are devoid of crystal boundaries, and show only the slightest traces of the basal parting. Small patches of the specimens are perfectly colourless and transparent, but the greater part is slightly milky white, with a translucency of about 10 mm., the milkiness being due to minute fluid inclusions.

Rosterite has been previously described from Wodgina.\*

\* E. S. Simpson, J.R.S.W.A. 15 (1929), p. 100.

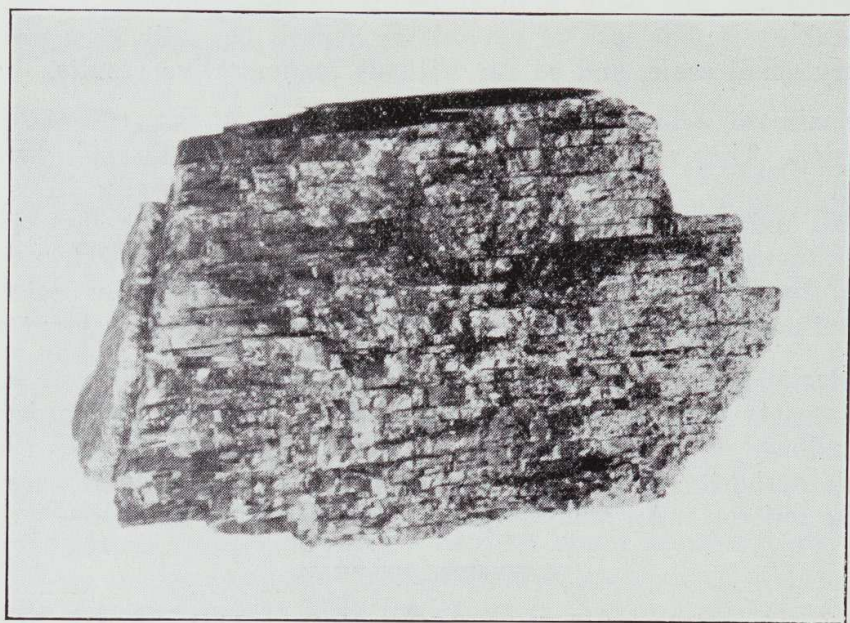


## (5).—GIGANTOLITE AND SPESSARTITE, MELVILLE, MUR.

Cordierite ( $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}$ ) is a mineral of very characteristic structure in large masses, and highly susceptible to hydrothermal alteration into muscovite, with or without biotite and chlorite. Pseudomorphs of more or less impure muscovite after cordierite retain the characteristic structure of the original mineral, and are known as "gigantolite."

As far back as 1923 the Writer collected some typical specimens of gigantolite in the outcrop of a quartz-microcline-albite-muscovite pegmatite at the N.W. corner of Harrisons Reward M.L. 26. In 1932 the locality was re-examined, as in the meantime ilmenorutile had been discovered in the same vein. Further gigantolite specimens were obtained, and for the first time a detailed investigation of them was made in the laboratory.

Masses of several pounds in weight were not uncommon in the pegmatite outcrop, all showing the typical cordierite structure, especially the strong basal parting, irregularly spaced at intervals of 1 to 5 mm. See Fig. 2. The prismatic cleavages are less distinctly represented. Most of



GIGANTOLITE PSEUDOMORPH AFTER CORDIERITE, MELVILLE.  
Scale of Nature.

*Photo., B. L. Southern.*

Fig. 2.

the specimens have a number of small garnets dispersed sporadically through them, whilst coarse flakes of muscovite and biotite show up on the basal parting, and to a less extent on the vertical cleavages.

The gigantolite is greenish grey in colour, and is either pale or dark in shade according to the relative proportions of the various mineral constituents. Sections in three directions of one of the darker grey specimens showed no unaltered remnants of the original cordierite. The main mass consisted of micro-sealy muscovite, in which were embedded some larger flakes of muscovite and bottle green biotite. The latter was particularly plentiful along the lines of parting, but was also scattered in small groups throughout the whole mass. A little coarsely crystallised ilmenite, partly



altered to leucoxene, is present. Included garnets (spessartite) are not uncommon, and when lying across a parting do not seem to have displaced it, but on the contrary show a continuation of it right through the crystal in the form of a band free, or almost free, from microscopic inclusions. This shows that the garnet formed subsequently to the crystallisation of the cordierite. The only other inclusions noted in the gigantolite are occasional flakes of green chlorite, and a plagioclase in small lenticular masses with albite twinning and low extinction angle, indicating oligoclase.

One of the least weathered fragments was chosen for chemical investigation. It was rather pale grey in colour, with many embedded garnets somewhat larger in size than usual, and easily separated from the matrix. The whole was carefully crushed in successive stages, all the garnets being separated from the matrix, and both subsequently analysed separately.

The results of the two analyses were:—

## GIGANTOLITE, MELVILLE.

					Micaceous Gigantolite.	Embedded Spessartite.
SiO <sub>2</sub>	...	...	...	...	44.50	38.66
Al <sub>2</sub> O <sub>3</sub>	...	...	...	...	29.12	20.14
Fe <sub>2</sub> O <sub>3</sub>	...	...	...	...	5.72	.96
FeO	...	...	...	...	2.52	6.52
MnO	...	...	...	...	.41	32.06
MgO	...	...	...	...	3.06	.10
CaO	...	...	...	...	.24	1.62
Na <sub>2</sub> O	...	...	...	...	.50	nil
K <sub>2</sub> O	...	...	...	...	9.84	nil
H <sub>2</sub> O +	...	...	...	...	4.35	.16
H <sub>2</sub> O —	...	...	...	...	.17	.02
TiO <sub>2</sub>	...	...	...	...	.04	nil
P <sub>2</sub> O <sub>5</sub>	...	...	...	...	.06	nil
CO <sub>2</sub>	...	...	...	...	.08	nil
					100.71	100.24
G	...	...	...	...	3.0 ±	3.985

Analysts: J. N. A. Grace C. R. Le Mesurier.

Calculation of the mineral composition of the main micaceous mass of the gigantolite, in the light of the analysis and microscopic examination, yields the following proportions of individual components:—

Muscovite	...	...	...	...	...	86 per cent.
Biotite	...	...	...	...	...	9 „
Ilmenite, Oligoclase, Limonite, Chlorite	...	...	...	...	...	5 „
						100 „

The embedded spessartite contains apparently a small proportion (5 per cent.) of siliceous impurities, seen under the microscope as a greyish dust. Allowing for this, the pure garnet molecules cocrystallised are:—

Spessartite	...	...	...	...	...	78.7 per cent.
Almandine	...	...	...	...	...	16.0 „
Andradite	...	...	...	...	...	3.3 „
Grossularite	...	...	...	...	...	1.7 „
Pyrope	...	...	...	...	...	.3 „
						100.0 „



This spessartite is in globular individuals with only rare traces of a rhombic dodecahedron face. The diameters range from 1 to 4 mm. The colour is pale brown on the surface, and paler brownish white on a fresh fracture. They were not observed in any part of the pegmatite except in the gigantolite masses. They are very like the spessartites associated with tin ore at Moolyella. This is the third species of garnet to be recognised within a radius of a few miles at Melville, the other two being andradite\* and grossularite.†

#### (6) PLYGORSKITE, DARTMOOR, MUR.

Palygorskite is a clay mineral closely related to Pilolite, and in describing specimens of the latter mineral from Wadara Hills in Series II. of these "Contributions"‡ the writer endeavoured to explain the relationship between them in the light of the modern theory of isomorphism. Assuming the two end members of the series to be the known mineral Halloysite ( $H_4Al_2Si_2O_9 \cdot 2H_2O$ ) and a hypothetical isomorphous mineral Picrocollite ( $H_4MgSi_2O_9 \cdot 2H_2O$ ) the following constitutions were suggested:—

Alpha-Palygorskite	...	...	...	...	Hal + Pic.
Beta-Palygorskite	...	...	...	...	Hal + 2 Pic
Wadara Pilolite	...	...	...	...	Hal + 3 Pic.
Alpha-Pilolite	...	...	...	...	Hal + 4 Pic.

A mineral recently collected at Dartmoor agrees very closely with the ratio for Beta-Palygorskite. It was found in two places, viz. on Hose's Loc. 7220, North Dartmoor, and on the Government Water Reserve 12648, South Dartmoor, 20 miles S.W. of Hose's.

The mineral at Hose's was got in considerable amount in the last 4 feet of a well 20 feet deep sunk in horizontally bedded sediments and yielding brackish water. The age of the rocks is not certain, but may be anything from Carboniferous to Cretaceous. The Writer did not see it in situ, but it was said by the proprietor to occur in "a thick seam at ground water level." Masses of it were lying on the dump up to 6 inches (15 cm.) in diameter.

Hose's palygorskite has the appearance of a tough creamy white to greyish white clay, but its unusual lightness and toughness were at once apparent. Subsequent tests in the laboratory showed that comparatively large fragments would float on distilled water until they became waterlogged. To the eye a fresh fracture appears dull, dense and structureless. That it is a mass of microscopic pores is, however, shown not only by the very low bulk specific gravity but by the strong adherence of one's tongue to it, and by the large amount of water it is capable of imbibing. When immersed in water it shows no inclination to swell, flake or crack. Its hardness is 1.5.

A single large lump of similar material was found alongside the Government water bore on Reserve 12648. The chief difference between this mineral and that on Hose's property was its greater hardness (2.0), toughness, and bulk specific gravity. Fragments sank immediately in water, but the porosity was still very high as judged by the strong adherence to the tongue, and increase in weight when soaked in water.

The powder of both minerals was identical in appearance under the microscope, consisting of slightly greyish translucent aggregates of extremely small birefringent flakes. The true specific gravity and mean refractive index were practically the same for both specimens.

\* E.S.S.: J.R.S.W.A. 14 (1928), p. 52. † Not yet described in print.

‡ J.R.S.W.A. 13, p. 42-43.



Analyses showed very little difference between the two after they had been coarsely crushed and well, but not exhaustively, washed with distilled water to remove the salts of the brackish waters with which they were associated. The results were:—

## PALYGORSKITE, DARTMOOR.

					Loc. 7220.	Res. 12648.
SiO <sub>2</sub>	...	...	...	...	55.76*	56.49†
Al <sub>2</sub> O <sub>3</sub>	...	...	...	...	10.69	10.07
Fe <sub>2</sub> O <sub>3</sub>	...	...	...	...	4.58	5.00
FeO	...	...	...	...	nil	nil
MnO	...	...	...	...	.01	trace
MgO	...	...	...	...	6.85	6.63
CaO	...	...	...	...	.09	nil
H <sub>2</sub> O +	...	...	...	...	9.04	9.51
H <sub>2</sub> O —	...	...	...	...	11.54	10.64
K <sub>2</sub> O	...	...	...	...	1.10	1.39
Na <sub>2</sub> O	...	...	...	...	.12	.32
TiO <sub>2</sub>	...	...	...	...	.56	.46
Cl	...	...	...	...	trace	trace
Total					100.34	100.51
G (true)	...	...	...	...	2.20	2.21
Nm	...	...	...	...	1.522	1.523

Analyst: H. P. Rowledge. C. R. Le Mesurier.

\* Includes 8.32 per cent. of quartz, rutile, etc., unattacked by fuming H<sub>2</sub>SO<sub>4</sub>, of which 0.96 per cent. does not vaporise with HF.

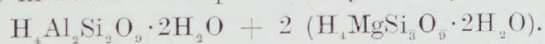
† Includes 10.66 per cent. of quartz, etc., of which 0.65 does not vaporise with HF.

Both minerals are decomposed by heating in powder with strong HCl or H<sub>2</sub>SO<sub>4</sub>. Quartz is readily detected under the microscope in the original powders, or by examination of the residues after acid treatment, followed by Lunge's solution. Under the latter conditions the titanium in the specimens is seen to be present as rutile. The potash may be simply adsorbed, or more probably present as muscovite. If the latter, it forms about 10 per cent. of the whole in the first, and 15 per cent. in the second.

Making allowance for these impurities, the ratios of MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub> and H<sub>2</sub>O to one another prove to be—

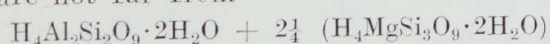
Source.	MgO	Al <sub>2</sub> O <sub>3</sub> *	SiO <sub>2</sub>	H <sub>2</sub> O ±
Loc. 7220 ...	1.92	1.00	8.09	12.44
Res. 12648	2.21	1.00	8.96	14.57

The former mineral corresponds very closely to—



which is the formula for Beta-Palygorskite.

More uncertainty is introduced into the calculation of the second mineral owing to the appreciable amount of soda present, only part of which is likely to exist with the potash in muscovite. The figures given are those based on an assumption that two-thirds of it are present as muscovite. The ratios so calculated are not far from—



In general, therefore, the analytical figures obtained appear to support the Writer's theory of the constitution of the Pilolite-Palygorskite series.†

\* Includes Fe<sub>2</sub>O<sub>3</sub>.

† Jour Roy Soc. W.A. 13, p. 43. Key to Mineral Groups, Species and Varieties, E. S. Simpson, 1932, p. 56, 58.



## (7) PETALITE, LONDONDERRY, CEN.

Whilst inspecting Scahill's felspar quarry on M.L. 72 at Londonderry this spring, the writer observed a hard, almost opaque white mineral, obviously not microcline, of which quite a ton had been thrown out on to the waste heap. This was traced to the south-western corner of the quarry, an excavation 50 x 50 x 12 feet, from which about 2,000 tons of high-grade microcline have been taken. The white mineral formed in situ (so far as could be seen) a large vertical tabular mass, associated with a parallel mass consisting of an intergrowth of coarsely crystallised lepidolite and albite, both close to, if not on, the wall of the microcline vein.

Close examination of the specimens collected indicated that the white mineral was a deep seated alteration product, pseudomorphous after a transparent colourless mineral, of which a few small unaltered cores remained. The well marked cleavage of this latter mineral, its low specific gravity (2.39) and refractive indices (1.516, 1.510, 1.503)\* pointed to its identity with Petalite,  $\text{LiAlSi}_4\text{O}_{10}$ , a mineral not previously found in Australia. This determination was confirmed by a chemical analysis.

## PETALITE, LONDONDERRY.

				Petalite.	Pseudomorph after Petalite.
$\text{SiO}_2$	...	...	...	76.19	74.48
$\text{Al}_2\text{O}_3$	...	...	...	16.48	15.52
$\text{Fe}_2\text{O}_3$	...	...	...	.21	.17
$\text{FeO}$	...	...	...	nil	nil
$\text{MnO}$	...	...	...	trace	nil
$\text{MgO}$	...	...	...	.54	.11
$\text{CaO}$	...	...	...	nil	.20
$\text{Li}_2\text{O}$	...	...	...	3.72	nil
$\text{Na}_2\text{O}$	...	...	...	.36	7.72
$\text{K}_2\text{O}$	...	...	...	.18	1.22
$\text{H}_2\text{O} +$	...	...	...	1.04	.40
$\text{H}_2\text{O} -$	...	...	...	1.22	.50
Total				99.94	100.32
G	...	...	...	2.38	2.61

Analyst: C. R. Le Mesurier.

Some of the least altered mineral that could be obtained was used for the analysis. It was highly transparent, colourless to very faint pink or lilac in colour, possessing a bright vitreous lustre, and one well marked cleavage (001). One cleavage fragment shows a rough face making an angle of 62 degrees with it, which may be  $z$  ( $\overline{905}$ ), since  $cz$  is recorded as 62 degrees 33 minutes. The mineral is very brittle, and has a hardness of 6.

Even the purest mineral is not completely unaltered. Examination with a lens reveals ribbons and threads of less transparent white material forming an open meshwork in it. This is a hydration product, as the analysis shows an appreciable percentage of unessential water, whilst a little alkali appears to have been leached out, the calculated ratios being—

	$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	$(\text{Li}, \text{Na})_2\text{O}$	$\text{H}_2\text{O} +$
Petalite, theory	8	1	1	nil
Petalite, Londonderry	8.10	1.05	0.85	0.35

These figures do not include the appreciable  $\text{MgO}$  whose role is unknown, but which may be present as montmorillonite.†

\* Determined by H. Bowley.  
Minl. Mag. 20, p. 141.

† Cf. W. F. P. McLintock, Petalite at Okehampton, Devon.



Petalite appears to be very susceptible to alteration under the influence of the hydrothermal activity which marks the final stages of pegmatite formation. At Londonderry at least three different pseudomorphs have been observed, viz.:—

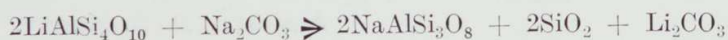
- (1) A hard lilac-coloured mineral, partly dense, partly cellular.
- (2) A softer and more brittle mineral of the same colour (montmorillonite?).
- (3) A hard dense and tough, milk white mineral.

The last is by far the most abundant, and is to be seen in masses many pounds in weight on the dump. It was this mineral which was found to enclose cores of petalite with indefinite boundaries between the two, and with the perfect cleavage of the original mineral continuing into the pseudomorph as a more or less pronounced parting. It is also the only one which has been examined in detail, the analysis of a typical piece being given above. As this pseudomorph occurs in the quarry in masses several hundredweight in weight, it is certain that petalite originally existed in similarly sized masses, and may be disclosed in large unaltered masses as quarrying proceeds.

Apparently homogeneous, the microscopic examination of powder and section of the pseudomorph shows it to consist of small interlocking grains of a colourless, transparent, birefringent mineral with a refractive index a little below 1.538, crowded with minute granules of a second mineral. The analysis permits this to be interpreted as a mass of microcrystalline albite (66 per cent.) with granular inclusions of quartz (25 per cent.), and probably some minute scaly muscovite and a "clay" (montmorillonite?) (9 per cent.). Occasional minute scales of the former and films of the latter are visible on the partings.

A second specimen had a specific gravity of 2.64, and contained 72.55 per cent. of silica.

If petalite were altered into albite according to the equation—



and 10 per cent. of the albite further altered into montmorillonite, thus—



and all the silica and montmorillonite left in situ, the resulting pseudomorph would contain albite 72 per cent., quartz 20 per cent., montmorillonite 8 per cent. This is not far from the observed proportions.

In mass the pseudomorph is easily distinguished from the primary microcline and albite of the vein. It has a peculiar, somewhat horny, lustre, is milk white, has a translucency of about 3mm. and a hardness well over 6. The basal cleavage of the original petalite is perpetuated as a much less perfect parting, which varies in intensity in different specimens, and even in different parts of the same specimen. In places it is closely spaced, 1 to 3 mm., in other places it is only observed at intervals of a centimetre or more, whilst individual planes do not always pass completely through the pseudomorph.

This pseudomorph is quite different to those which have previously been described in the literature, viz., hydrocastorite in Elba, and montmorillonite in Devonshire.



Except for two doubtful records, petalite has previously been found in only six localities throughout the world, viz.:—(1) Utö, Sweden (type locality); (2) San Piero, Elba; (3) Okehampton, Devonshire; (4) Amanaus Glacier, Caucasus, Russia; (5) Bolton, Massachusetts; (6) Peru, Maine. The doubtful localities are:—(7) Roschitz, Moravia, Czecho-Slovakia; (8) York (near Toronto), Ontario.

#### (8) TOPAZ, MELVILLE, MUR.

Early in 1932 a prospector (O. Drew) discovered what he took to be barite in a pegmatite vein just south of the place known as "The Basin," at Melville. Examination in the laboratory showed that the mineral was topaz. Later in the same year the writer visited this find, and discovered more topaz in another vein about 200 yards south of the first find, and muscovite pseudomorphs after topaz in both places. Still later Drew found topaz again on Harrison's Reward M.L. 26, about 1½ miles north-west of the first find.

In the first vein, which is on the outer slope of the southern rim of The Basin, the mineral occurs in a quartz-microcline-albite pegmatite. It is in colourless, or slightly milk white, masses up to several pounds in weight. That each of these is a single crystal individual is shown by the continuity of the distinct basal cleavage. The only crystal outlines observed were some isolated groups of striated prism faces. Parts of the masses are completely colourless and transparent in a thickness of 5 mm., and for the most part the translucency reaches to 10 mm.

An analysis was made of some of the cleanest, almost colourless mineral. The figures obtained were:—

#### TOPAZ, MELVILLE.

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	F	H <sub>2</sub> O +	H <sub>2</sub> O —
32·80	54·66	·28	nil	nil	18·55	·87	·05
Total.		Less O ≡ F	Net Total.		G		
107·21		7·81	99·40		3·54		
Analyst: D. G. Murray.							

This yields a molecular ratio of:—

	Al	:	F + OH	:	Si
Melville Topaz ...	2·00		2·00		1·04
Theory ...	2		2		1

In addition to the minerals already mentioned the vein carries some green beryl and a little manganotantalite.

In a second vein just south of the above, colourless topaz occurred under similar conditions, this time with a pale yellow beryl. The only specimen received from the third locality was similar to that from the first, being slightly milky white with considerable translucency.

One of the most interesting points about all three occurrences of topaz is the extent to which the mineral has been altered into pseudomorphous muscovite in a later stage of the history of the veins, when apparently they were invaded by hot alkaline solutions rich in potash.

In the first vein, apart from large masses of pure unaltered topaz, there are many masses consisting of a core of topaz completely surrounded by a thick layer of soft, but tough, cryptocrystalline muscovite. In a typical



specimen the unaltered core has a rounded rhomboid cross section, measuring 6 x 4 cm. at the middle, and tapering off at each end to about 2 x 1½ cm. This core breaks out cleanly and sharply from the enclosing muscovite shell in which it is not quite centrally situated. The encrusting layer of mica varies in thickness from 0.3 to 2.0 cm.

In a specimen from the second vein a similar micacisation is much further advanced, the pseudomorphous muscovite reaching 3 cm. in thickness. Here, instead of forming a sharp boundary with the parent mineral, it penetrates the latter in tongues and loops.

At the third locality also advanced stages of micacisation have been observed in addition to almost completely unaltered mineral. This further evidence of a late potassic phase in the formation of pegmatites in this district supports that already observed above in the conversion of primary cordierite into muscovite and biotite in a pegmatite on Harrison's Reward Lease, and in the widespread conversion of amphibole into biotite on the walls of the pegmatite veins.

### SUMMARY.

A description is given of the occurrence in Western Australia of the following minerals, with analyses and details of physical properties, genesis, etc.

(1) Antimony ochre, Wiluna. A dense mixture of stibiconite, cervantite, atopite (?) and quartz. (2) Apatite, barite and glauconite, in Cretaceous beds, Gantheaume Bay. The apatite occurs as coprolite pebbles and apatised coniferous wood. (3) Native arsenic, in a gold lode, Kalgoorlie. (4) Beryl (common beryl, emerald and roosterite), Melville. The emerald found is promising, but not yet commercial. (5) Gigantolite and spessartite, Melville. The latter is embedded in the former, which is a pseudomorph after cordierite. (6) Palygorskite, Dartmoor. The first record for Australia. Analyses confirm the Writer's theory that this mineral is a co-crystallisation of halloysite and pierocollite. (7) Petalite, Londonderry. The first record for Australia. The original mineral and a common pseudomorph are described. (8) Topaz, Melville. Details are given of the primary mineral and a muscovite pseudomorph.



